Correlating soft X-ray and γ-ray emission in Orion

M.J. Freyberg, V.A. Dogiel, G.E. Morfill, V. Schönfelder

The discovery of soft γ-ray emission from the Orion complex in the $3-7\,$MeV range by COMPTEL, was supposed to give the first evidence for γ-ray lines generated by cosmic rays in the interstellar medium (see references in Dogiel et al. 1997a). The data did not exclude the excess interpretation as a continuous spectrum of γ-ray emission with a break near the energy 7 MeV (this interpretation is discussed by Dogiel et al. 1997c). The γ-ray line emission should be accompanied by production of secondary knock-on electrons which generate bremsstrahlung radiation in the X-ray energy range (solid line in right figure) (Dogiel et al. 1997b). Detecting this non-thermal flux of X-ray emission from Orion would confirm the diffuse γ-ray origin of the excess.

To determine the spatial extent, photon index, and normalization of non-thermal diffuse X-ray emission from knock-on electrons we analysed the X-ray background spectra of all public PSPC data sets of the Orion region in the energy range $0.5-2.0\,$keV (circles in left figure, overlaid on COMPTEL image). We excluded all point-like sources with significance $> 4\sigma$ from our analysis. With an adopted distance of $d \sim 500\,$pc we obtained an upper limit for the diffuse X-ray luminosity produced by knock-on electrons of $\sim 1.3\times10^{33}\,\mathrm{erg\,s^{-1}}$ in the range $0.5-2.0\,$keV, where normal interstellar absorption has already been taken into account. This upper limit is somewhat less than the expected value of $\sim 6\times10^{33}\,\mathrm{erg\,s^{-1}}$ (right figure). The difference between the calculated luminosity and that one estimated from ROSAT data is not large enough to draw a final conclusion in favour or against the γ-ray line model. Additionally, the observed spatial extent of the excess X-ray emission is only a couple of square degrees and thus much smaller than the assumed γ-ray emission region. The X-ray excess is close to the Orion Nebula (contributions of unresolved sources cannot be excluded). Finally, a lack of correlation of γ- and X-ray emission, in some regions even an anti-correlation, is observed. Possible implications of the discrepancies in spectral and spatial correlation can be discussed in terms of intrinsic absorption, ISM enrichment by oxygen and carbon, and inhomogeneous γ-ray emission.

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